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GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Differential and Genetic Psychology

THE EFFECT OF DELAYED INCENTIVE ON THE HUNGER DRIVE IN THE WHITE RAT*[1]

From the Animal Laboratory of the Department of Psychology, Columbia University

By

E. LOUISE HAMILTON

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY, IN THE FACULTY OF PHILOSOPHY, COLUMBIA UNIVERSITY

*Received for publication by C. J. Warden of the Editorial Board, November 2, 1928.

[1]This report covers one major topic in a project on animal drives (under the general direction of Professor C. J. Warden) supported by the Council for Research in the Social Sciences of Columbia University.

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Columbia University
New York City

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I

INTRODUCTION

In experimental studies of animal motivation, the organism is usually required to perform some task in order to obtain the incentive. Ordinarily, the latter is accessible to the animal immediately upon completion of the performance. This is perhaps the best procedure for most experimental work on animals, since a more favorable emotional adjustment to the artificial laboratory situation tends to be made under this condition. An interesting problem from the standpoint of general motivation, however, is that of separating the incentive stimulus from the required performance by various intervals of time, thereby introducing the factor of delayed incentive. The question arises as to the effect of various intervals of delay between the performance of the task and the incentive on the strength of the drive under investigation. Is the drive weakened, strengthened, or in no way affected when the reward does not immediately follow the performance?

In the measurement of drives[2] two principal methods have been used. The Obstruction Method, developed

[2]The term "hunger drive," as used in this study, has specific reference to the tendency of the animal to search for the food as indicated by behavior indices and not to the physiological state of the organism underlying the drive for which no independent, direct index was obtainable. The term "incentive" refers to the food stimulus, while "incentive value" or "incentive index" denotes the stimulation effect of the incentive in terms of behavior. None of the preceding terms carries any implications whatsoever concerning the subjective state of the organism.

in the Animal Laboratory of Columbia University and used in a comprehensive study of drives (hunger (10), sex (11), segregation (3), and thirst (12)) in the white rat, is doubtless the most direct method so far developed. No study has as yet been made on the effect of delayed incentive on drive, since in all cases the animal has been given immediate access to the incentive after crossing the grid. The second method, the Learning Method, consists in the measurement of the drive indirectly in terms of its effect on the rate of learning. This method has been employed in the study of the effect of delay in the case of one drive only—hunger.

Watson (14) was perhaps the first to attack the problem of the relation of motivation to learning by means of this method. The apparatus employed was a modification of the sawdust box provided with a device for restraining the animal from obtaining the food until an interval of time had passed. The food was placed in a cylindrical container 5 cm. in diameter and 3 cm. high, supplied with a lid perforated with several mm. holes to allow for olfactory stimulation. A small vertical rod was screwed into the center of the lid and passed through a hole in the wire mesh of the problem box, passing out through the top. By means of this rod the experimenter could allow the animal to get food after a given interval.

He used 6 male rats approximately 60 days of age and 6 male rats about 100 days of age. The twelve animals were divided into two groups, six of which had to learn the problem by the usual method of immediate feeding and six others by the method of

delayed feeding. The animals were distributed at random into the two groups, with the only precaution that each group contained three young animals and three older ones.

As preliminary training, all twelve animals were allowed to get their food in the box a number of times before the training series. At all times during the tests the lid to the food box was left on in the case of both groups. The lid was lifted by the time the animals reached the food box for the control group. The animals of either group were allowed to eat for five seconds on each trial after entering the box and then were lifted out and taken back to their living cages. Only one trial per day was given. The same method was adopted for the delayed incentive group except that in this case the lid to the food box was held down for 30 seconds. Watson found that the animals were very active during the period of delay. Table 1 shows the average time per trial for the two groups. Examination of the data indicates that a delay of 30 seconds between the solving of the problem and obtaining the incentive (food) has no effect upon speed of forming this habit. Such decided changes in procedure as the increase of trials to two trials per day and an interchange of incentive conditions between the immediate and delayed groups produced no noticeable effect upon the results.

Simmons (6), in her study of the effectiveness of various incentives in animal learning, made a brief test of the effect of delayed feeding on the learning of a complex maze. She used five male and five female

TABLE 1

Table from Watson Showing Average Time per Trial

Trials	Average delayed feeding Seconds	Average immediate feeding Seconds
1	385	923
2	58	111
3	84	89
4	30	24
5	18	36
6	17	23
7	13	9
8	12	13
9	9	8
10	9	15
11	13	9
12	8	13
13	8	9
14	9	7
15	11	24
16	7	8
17	6	9
18	8	6
19	10	5
20	9	5
21	8	6
22	6	6
23	8	7
24	6	7
25	6	8
26	6	7
27	7	6
28*	5	4
29	5	5
30	5	5
31	4	5
32	4	4
33	3	4
34†	6.3	3.6
35	4.0	4.3
36	4.6	4.3
37	6.0	5.3
38	3.3	3.3
39	3.3	4.3
40	5.0	5.3
41	3.3	4.3

*At this trial the two-trials-per-day schedule was introduced.

†At this trial the delayed group was fed immediately and the control group delayed 30 seconds. Only three animals (60 days of age) of each group were included.

albino rats between three and four months of age. The rats were selected by chance so that the two groups represented random samples with the exception that each group had approximately an equal number of males and females. As preliminary training, the rats were fed in a special feeding cage, for 7 to 10 days before the experiment was begun, at the same time of day at which they were later fed during the experiment proper. Two groups were run, a standard and a delayed group. The former were fed, during the training period, immediately after practice each day, as is usual in ordinary laboratory procedure. The delayed group were fed in the feeding cage one and one-half to two hours after the last run. Work was done in the late afternoon by electric light. Two trials per day were given to each group, and the maze was considered mastered at that trial after which nine out of ten successive runs were made without error. The results appear in Table 2. The immediate feeding

TABLE 2

TABLE FROM SIMMONS SHOWING AVERAGES WITH INITIAL TRIAL OMITTED

Conditions	Trials	Errors	Time
Immediate feeding	27.8	127.7	1761.44
Delayed feeding	33.3	93.3	1105.10

group had records slightly superior in respect to number of trials, but inferior in respect to time and errors. Simmons does not consider these differences large nor, in view of the large mean deviations and lack of agreement between the three criteria, very significant. Also the difference in error score between the groups was

confined largely to the first five trials and the records were almost coincident thereafter. She concludes that there is no significant difference between the records obtained under the two conditions.

A former study (8) made by the writer dealt with the effect of short intervals of delay in feeding upon speed of maze learning. The subjects were 43 white rats approximately 8 weeks old and 80 grams in weight. These were divided into three groups, a control group of 15 animals and two test groups of 14 animals each. The apparatus used was the Warden maze containing eight culs-de-sac in a simple straightaway pattern. The device utilized for restraining the animal from obtaining the food during the period of delay consisted of a heavy metal funnel 9 cm. in diameter, lined with felt, which could be dropped down over the food dish at will. The latter consisted of a metal bell, from an alarm clock, about 6 cm. in diameter, which was screwed down to the floor at the center of the food box. A wooden screen, formed by extending the sides of the food box upward for a distance of 18 inches, served to isolate the animal from possible distracting stimuli and also to rule out the experimenter. The screen was provided with a door for the removal of the animal from the food box. The funnel was heavily weighted with lead so that it could not be removed from the dish by the animals. It was operated by means of a wire cable which extended outside the food box. Perforations in the funnel permitted normal olfactory stimulation during the delay period. Two intervals of delay were studied, a 1-minute and a 5-minute interval.

TABLE 3

TABLE FROM WARDEN AND HAAS SHOWING RESULTS FOR EACH GROUP*

Group	Median	Averge	S.D.	S.D. (Av.)	$\frac{d}{S.D._d}$		V.
			TRIALS				
Control	10.0	10.6	2.2	0.6	Con. & 1 Min.	2.00	20.6
1 Min.	12.0	12.4	2.8	0.7	1 Min. & 5 Min.	2.40	22.6
5 Min.	10.0	10.2	2.2	0.6	Con. & 5 Min.	0.04	21.6
			ERRORS				
Control	22.0	24.7	6.8	1.8	Con. & 1 Min.	2.3	27.5
1 Min.	29.5	31.2	8.4	2.2	1 Min. & 5 Min.	2.9	26.9
5 Min.	24.5	24.0	4.7	1.3	Con. & 5 Min.	0.3	19.6
			TIME				
Control	237.0	232.5	34.8	9.0	Con. & 1 Min.	2.8	15.0
1 Min.	263.5	294.9	75.3	20.1	1 Min. & 5 Min.	0.7	25.5
5 Min.	263.5	275.6	61.5	16.4	Con. & 5 Min.	2.3	22.3

*The data here presented include only Norm B (four perfect trials out of five) of the former study since the conclusions drawn there were based wholly upon the scoring by this norm.

As preliminary training, the animals were allowed to feed, on each of three days previous to the training period, for five minutes in both the entrance box and the food box and then for a like period in the adjacent feeding cage.

One trial per day was given. The training was continued until four out of five trials were made without error. The difference in procedure was as follows. In the case of the control group the funnel was raised exposing the food the instant the door was closed behind the animal. After 5 minutes' feeding the rat was removed through the door in the screen and placed in a small cage, with food, for an additional 5 minutes and then returned to its living cage. The procedure in the case of the two test groups was precisely the same, except for the fact that in each case the funnel was

raised only after the interval of delay was over. The results are presented in Table 3. The control and 5-minute groups had practically the same scores when trial and error data are considered. The time data show that the 5-minute group spent more time in the maze. The writers do not believe this small difference bears any essential relation to the rate of fixing the maze habit. The 1-minute group, however, showed a slower rate of learning with differences fairly reliable in most cases. Since this group was more variable than the other groups, they question the validity of the indices of this group and leave the matter open for further investigation. The only conclusion reached was that a 5-minute interval of delay between the act to be fixated and the feeding response had no measurable effect upon the rate of fixation.

It will be seen from the above that very little work has been done on the effect of delayed incentive on the rate of learning. Watson's study was limited to a single delay interval of 30 seconds and Simmons' to one of approximately 2 hours. In neither case was a sufficient number of animals used to secure conclusive results. The former study of the writer is the most extensive one reported up to the present time so far as the number of intervals of delay introduced is concerned, and the groups used were approximately twice as large as those used by Watson and Simmons. As before stated, the more direct measurement of the effect of delayed incentive by means of the Obstruction Method had not been attempted previous to the present experiment.

In the present study, both general methods of studying drives were employed to determine the influence of relatively short intervals of delay on the hunger drive. The Obstruction Method employed the Obstruction Apparatus, and the Learning Method, a maze. These will be treated in the following order:

Section II. Experiment 1—The Obstruction Method.

Section III. Experiment 2—The Learning Method.

Section IV. Discussion and Comparison of Obstruction and Learning Methods.

II

EXPERIMENT 1

THE OBSTRUCTION METHOD

A. Method and Procedure

Apparatus. The apparatus employed in Experiment 1 was the Obstruction Apparatus which has been fully described by Jenkins, Warner, and Warden (4). It consists of three compartments: *A,* the entrance compartment; *B,* the obstruction compartment; and *C, D,* the divided incentive compartment. In the present study, compartment *C* was used as a delay compartment and compartment *D* as the incentive compartment.

The relative positions of these divisions of the apparatus can be readily seen in Figure 1. The obstruction compartment was separated from the entrance compartment and from the delay compartment by sheet metal doors (d_1, d_2) which were operated manually by means of strings leading outside the box. The strings passed out through curved glass tubes in such wise that the hand of the experimenter in manipulating the door was entirely out of view of the animal. The bent glass tubing was found to be superior, that is, more nearly noiseless than the usual type of pulley device. The delay compartment was separated from the incentive compartment by an automatic door (d_3) which was operated by the test animal when it stepped on a release (E) immediately after passing through the obstruction

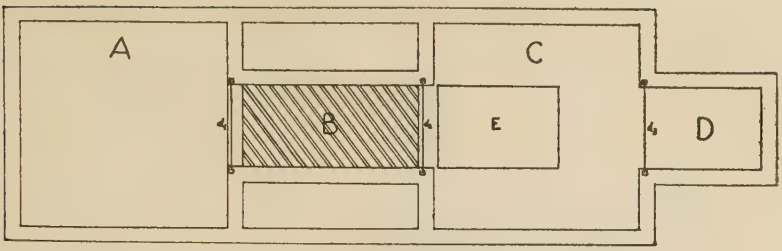

FIGURE 1

DIAGRAM OF FLOOR PLAN OF OBSTRUCTION APPARATUS

A, entrance compartment; *B*, obstruction compartment; *C*, delay compartment; *D*, incentive compartment; *E*, release plate; d_1, manually operated door of entrance compartment; d_2, manually operated door between obstruction and delay compartments; d_3, automatic door (operated by release plate) between delay and incentive compartments.

compartment. This door was composed of translucent mathematical celluloid, and permitted free passage of odors through ample perforations made in it.

The entire floor of the obstruction compartment consisted of an electric grid made of copper strips 1/8 in. thick and 3/8 in. in width running diagonally across the floor of the compartment. These strips were placed at regular intervals of 1/8 in. The grid could be electrified in either of two ways: (1) directly, by a switch operated by the experimenter; and (2) indirectly, by the automatic device which electrified the grid simultaneously with the closing of the door (Figure 1, d_1) between the entrance and obstruction compartments. This device, which was developed by T. N. Jenkins and first employed by Marion Jenkins (3), was also used in the present study, as in the study of the normal hunger drive (10), in giving the animal its first shock on the fifth trial of the preliminary training.

The compartments were covered with glass plates, which rested in felt-lined grooves so that they could be moved noiselessly by the experimenter when the animals were introduced into or removed from any compartment of the apparatus. The body of the apparatus was painted a flat black to insure as uniform illumination as possible. It was placed upon a table in a dark room. The illumination hood, placed 11 inches above the center of the apparatus, constituted the only source of light and afforded uniform lighting for all parts of the apparatus. Since the experimenter stood in the shadow and the animal in the light, the influence of the experimenter was ruled out without the necessity for a screen and peep-hole, which is customary in animal experimentation.

The degree of shock used was as follows: alternating current of 60 cycles, a terminal pressure of 475 volts, an external resistance of 10,100,000 ohms. The current was thus 0.047 milliamperes. This degree of shock was employed since it has proved satisfactory in work by previous investigators on the sex and hunger drives in connection with the Obstruction Apparatus and has been used in all the separate studies included under the motivation project.

Animals. The animals used in this part of the investigation were 100 albino rats of the "Experimental Colony Strain" of the Wistar Institute of Anatomy, Philadelphia. They were raised for us by the Institute until they reached the age of about 150 days, when they were shipped to us. Up to this time they had been kept in groups of from 5 to 10 unsegregated as to

sex, an approximately equal number of males and females making up each group. Upon arrival at our laboratory, they were segregated to the extent of placing males and females in separate cages in which condition they were kept until they reached the age of about 185 days. All animals fell within the age range of 175 to 196 days at the time of experimentation. The age range at the time of segregation was 143 to 157 days. The segregation period extended from 32 to 39 days. This period provided ample time for the animals to become accustomed to the laboratory conditions and also insured the availability of non-pregnant females for use in the experiment, since litters are born about three to four weeks after the animals have become pregnant.

The animals were fed a well-regulated diet before they were received by us. In our laboratory they were fed McCollum's Standard Diet (see 11, p. 27) with the addition of a weekly ration of greens. More than a sufficient amount of food was kept in the cages to insure uniform conditions with respect to hunger. We could be practically certain that, when the starvation period began, the animals were all at about the same stage of hunger. A small dish of McCollum's diet was also used as the incentive in the experiment. Fresh water was supplied daily in inverted bottles with nozzles to prevent fouling. The animals were thus always supplied with water, even during the 48-hour starvation period preceding the test. At the beginning of a starvation period, fresh sawdust was provided to insure complete absence of food. The general laboratory

conditions were precisely the same as those obtaining in all other studies coming under the project.

Four periods of delay, 15 seconds, 30 seconds, 1 minute, and 3 minutes, were investigated, groups of 20 animals being used in each cage. The 48-hour starvation group representing the maximum strength of the hunger drive (10) was employed as a control. The exactitude of the procedure followed, in connection with the Obstruction Apparatus in this series of researches, clearly warrants the use of the scores from one experiment to another as here employed (9). The grouping of the animals is shown in Table 4. It will be seen from the table that, although 11 males were used in the delay groups, only 9 females were employed in these groups. The reason for this is a practical one. The females could be used only when in dioestrum, a stage in the oestrous cycle, determination of which will be discussed below in connection with procedure. This stage could not be detected before testing since the smears were not made until after the animal was tested. A large number of females which had been run could not be used. Only 36 females out of 101 tested proved to be clearly in dioestrum. Naturally, the records of those in some stage of oestrum had to be discarded since the scores on such animals involved both hunger and sex drive. This difficulty does not arise with the males and hence male groups could be easily made at any desired size.

The starvation period was constant for all groups, consisting of a 48-hour interval during which the animals received no food, directly preceding the test

period. This interval was employed, since it represented the maximum strength of the hunger drive, as above stated, and individual and group differences should best be brought out by the use of maximal drive conditions.

TABLE 4

GROUPING OF ANIMALS

Length of delay period	Number of animals		
	Male	Female	Total
0 (Control)	10	10	20
15 Seconds	11	9	20
30 Seconds	11	9	20
1 Minute	11	9	20
3 Minutes	11	9	20

Procedure. The sex drive was controlled in the males by use of the segregation period of 35 days, which insured uniform sex deprivation. Since Warner (11) found that the sex drive in the male is at its minimum with the longest interval of sex deprivation he studied (28 days), we assumed that with a still longer interval of 35 days it would probably be still weaker or at least as weak as at 28 days. This would insure little interference or complication by the sex drive. In the case of the females, the matter of dioestrum was determined by the use of the smear technique developed by Long and Evans (5) and employed in the drive studies in the Columbia laboratory. Only those animals in the inactive period (dioestrum) were used. As mentioned above, this necessitated discarding the data on a large number of females. Determination of the oestrous condition was made from both the quick smear and the permanent slide by the ex-

perimenter. Dr. Warner, who has had considerable experience with the technique, checked the determinations. In all cases the determination was made on the basis of the histological picture and without consideration of the behavior data. To eliminate olfactory stimulation connected with the opposite sex, animals of only one sex were run on any one night and the box was washed with soap and water and allowed to air after each night's experimentation.

Time of day was controlled by testing all animals between the hours of 9 P.M. and 4 A.M. Since the laboratory was practically deserted at this time, noise distractions were also reduced to a minimum. The temperature of the laboratory was kept fairly constant by thermostatic regulation.

The method of handling the animals was made uniform by previous training in which the method of picking up the animal and transferring it at a constant rate to the entrance compartment was reduced to a habit. The time for moving the animal from the incentive compartment back to the entrance compartment was about 30 seconds. Naturally, the fact of emotional arousal in motivation situations makes it necessary to take every precaution to avoid distractions of every sort.

The preliminary training given the animals did not differ from the usual procedure with the Obstruction Apparatus. The animal was placed in the entrance compartment and after 10 seconds was allowed to cross the grid, which was not electrified, to the food in the incentive compartment. After the animal had

obtained a nibble of food, it was removed and again placed in the entrance compartment. After four crossings to the food in this manner, the animal was placed in the entrance compartment, but this time, upon clearing the door between the entrance and obstruction compartments, the animal received a shock from the grid. The shock was given by means of the indirect method of electrifying mentioned above in connection with description of apparatus, the closing of the door (d_1) automatically causing current to flow in the grid. After the animal had obtained a nibble of food on the fifth trial, it was removed from the incentive compartment and the test period began. An exception to this procedure was made in the case of such animals as did not take a nibble of food upon reaching the incentive compartment but engaged in exploratory activity by climbing up the sides of the box, etc. If the animal had not taken a nibble of food at the end of 60 seconds, it was removed, nevertheless, and replaced in the entrance compartment. The exception was also observed in the study of the normal hunger drive (10) from which our control group was taken.

The procedure for the test period for the control group consisted in placing the animal in the entrance compartment and after 10 seconds releasing it into the obstruction compartment as in the case of the preliminary training. However, the animal now received a shock as soon as its feet made contact with the grid, since the direct method of electrification described in the preceding section had been set in operation for this and all later tests. The following types of behavior,

which are characteristic for the Obstruction Method, were recorded on suitable blanks minute by minute: approaches, contacts, crossings.

An "approach" refers to orientation of the animal before the grid with its head projecting into the obstruction compartment followed by withdrawal without touching the grid. A "contact" refers to the touching of the grid by the animal followed by immediate withdrawal again. A "crossing" refers to the crossing of the grid by the animal and its entrance into the delay compartment. Quantitative data on these three types of behavior during a period of 20 minutes were recorded. Whenever a crossing occurred, the animal was removed from the incentive compartment after the usual nibble of food and returned to the entrance compartment. It was not detained for 10 seconds before being released into the obstruction compartment as before, but was allowed immediate access to the grid.

The procedure for the test period in the case of the delay groups was similar to that for the control group with the exception that the animal was not allowed immediate access to the food. Upon crossing the grid, the animal was held in the delay compartment for an interval of time, at the end of which it was permitted access to the food. In order to retain the animal during the interval of delay, d_3 was disconnected from the automatic release (E) and operated manually. The operation of the door by the experimenter, after the period of delay, soon became mechanical, so that as soon as the stop-watch indicated the end of the delay

period, the door was opened immediately. The animal was allowed a nibble of food and was returned to the entrance compartment after each crossing and delay period.

Quantitative behavior in the form of approaches, contacts, and crossings for a period of 20 minutes was recorded, as in the case of the control group. This time was exclusive of the delay periods. A cumulative stop-watch was used to measure the time of the 20-minute period. A second stop-watch was used to time the delay periods. The cumulative watch was started at the beginning of the test period. When an animal entered the delay compartment, the watch was stopped and the second watch started. At the end of the delay period the second watch was stopped and the cumulative watch started again. When the latter registered 20 minutes, the test period was considered completed. Thus, regardless of the number of delays, the time during which the test animal was exposed to the incentive and might cross to it was the same for all groups, including the control group. In addition to the quantitative data, notes were made on the behavior of the animals during the delay period. Each animal's weight was taken and recorded before the period of starvation and again after testing.

B. Results

The results are presented in Tables 5, 6, 7, 8, and 9 and in Figures 2 and 3. Table 5 gives the frequency distributions covering approaches, contacts, and crossings for the various periods of delay. It reads as follows: In the control or 0-delay group, there were

TABLE 5

FREQUENCY DISTRIBUTIONS COVERING APPROACHES, CONTACTS, AND CROSSINGS FOR THE VARIOUS PERIODS OF DELAY

Group	0				15 Seconds				30 Seconds				1 Minute				3 Minutes			
Number of responses	Approaches		Contacts		Crossings		Approaches		Contacts		Crossings		Approaches		Contacts		Crossings		Approaches		Contacts		Crossings	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
0	3	2	1	1					1								1			1		4		
1	1			1						2					1	3				1	1			
2	0	3		1					1	1					1		2	1	1				2	3	3	5
3	2	1			1	1					1	2				4			1		2		2	1		
4	1	1	2	1		0			2								1					1			1	
5	1	1	2	3	1				1	3	1	2			2	2		2			1	3		1			
6	2	1	1	0	0	0				2					2	1	1			1		1	1	1			
7	0	0		1	0	0		1			2				3	1					1	1	1	1	1		2
8			1	1		1	1	1		1				1	1	1		1	1			1	1				2
9		1				0		1	1					1						1			1				
10			1				1		1		1			1			1	1							2		
11						1		1		2	1	1		1			1	1					1	1	2	2	1		2
12			1	1					1		1		1			1					1		1		1			
13								1				2						1		2			1					
14								1				3								1		1						
15			1		1	1								2				1		2		1						
16							2				1	1								1			1					
17					1		1	2										1	2				1	1				
18					1	2					1			1						1					2			
19						1	1																		1			
20								1	1								1	1	2				1					
21					1	1							1	1			1											
22													1												1			
23						1	1																					
24												1	2															

Group	0				15 Seconds				30 Seconds				1 Minute				3 Minutes			
Number of responses	Approaches		Contacts		Crossings		Approaches		Contacts		Crossings		Approaches		Contacts		Crossings		Approaches		Contacts		Crossings	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
25					1	1													1	2				
26																								
27																								
28					1																			
29					2				1	1														
30							1		2	1														
31													1											
32																								
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38							1			1														
39										1														
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41																			1					
42																								
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44																								
45													1											
46																								
47																			1					
48																								

3 females and 2 males who made no approaches, 1 female and 1 male who made no contacts, and no females or males who made no crossings, etc.

Table 6 presents the measures of central tendency and variability for each delay period, including the median, range, average, standard deviation, and coefficient of variability of approaches, contacts, and crossings for each sex and for the combined (male and female) groups.

Table 7 gives the measure of reliability of the difference between the average crossings of various groups.

Table 8 shows the distribution of approaches, contacts, and crossings during the 20-minute test period, for the various groups, minute by minute. It reads as follows: The control group during the first minute made 7 approaches, 4 contacts, and 29 crossings, etc.

Table 9 gives the distribution of approaches, contacts, and crossings during the 20-minute test period in 5-minute intervals, in terms of absolute scores and percentages.

The graph presented in Figure 2 shows the average number of crossings, contacts, and approaches at each period of delay for the combined (male and female) groups.

Figure 3 presents graphically the distribution of crossings during the 20-minute test period in 5-minute intervals.

If we examine the scores on average crossings (Table 6) for the combined groups and the graph (Figure 2), we note that there is a decided drop with a 15-second delay. An animal subjected to such a small

TABLE 6
RESULTS FOR EACH DELAY PERIOD

Period of delay	Sex	Approaches					Contacts					Crossings				
		Median	Range	Average	S. D.	Coefficient of variability	Median	Range	Average	S. D.	Coefficient of variability	Median	Range	Average	S. D.	Coefficient of variability
0	Female	3	0-6	3.4	1.56	46	5	0-15	6.9	1.87	27	18	3-29	19.0	8.91	47
	Male	2	0-9	3.3	1.47	44	5	0-12	4.9	1.59	32	18	3-25	16.1	6.56	41
	Total	3	0-9	3.35	2.81	84	5	0-15	5.9	3.92	66	18	3-29	17.6	7.78	44
15 Sec.	Female	17	10-38	20.3	9.85	49	5	0-20	7.3	5.79	79	10	3-18	9.9	4.68	47
	Male	14	7-34	16.4	8.36	51	5	1-11	5.5	3.31	60	13	3-16	10.1	4.78	47
	Total	16.5	7-38	18.2	9.28	51	5	0-20	6.4	4.68	73	11	3-18	10.0	4.67	47
30 Sec.	Female	24	12-39	25.7	7.10	28	6	2-8	5.9	1.68	28	2	1-11	4.2	3.71	88
	Male	15	8-38	18.5	9.45	51	5	1-12	5.1	2.94	58	11	2-21	11.5	6.01	52
	Total	21.5	8-39	21.8	9.19	42	5.5	1-12	5.5	2.48	45	7	1-21	8.3	6.27	76
1 Min.	Female	17	2-45	19.7	13.81	23	2	0-7	2.7	1.99	74	7	2-17	7.3	4.47	61
	Male	15	6-20	14.5	4.08	28	6	1-15	7.3	4.39	60	11	2-20	10.8	5.27	49
	Total	15.5	2-45	16.8	10.08	60	5	0-15	5.3	4.17	79	8.5	2-20	9.3	5.22	56
3 Min.	Female	18	7-48	19.7	11.50	58	3	1-12	5.0	3.68	74	3	1-12	4.9	4.23	86
	Male	11	0-41	17.2	12.36	72	1	0-5	1.4	1.51	108	3	1-12	4.5	3.77	83
	Total	15	0-48	18.3	12.04	66	2	0-12	3.0	3.18	106	3	1-12	4.7	3.99	85

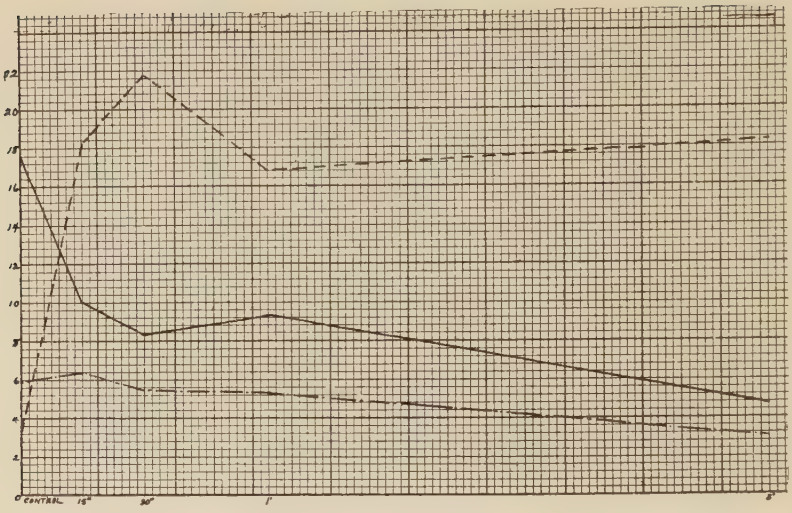

FIGURE 2

AVERAGE NUMBER OF CROSSINGS (SOLID LINE), CONTACTS (DOT-DASH LINE), AND APPROACHES (DASH LINE) AT EACH PERIOD OF DELAY FOR THE COMBINED (MALE AND FEMALE) GROUPS

amount of delay crosses on an average of 10.0 times, while an animal which is allowed to proceed immediately to the incentive crosses about 17 times, indicating a decrease in the drive with delay.

The scores on average approaches show the following tendency: An animal with 15 seconds' delay approaches about 18 times, while one which is not delayed approaches about 3 times. This tendency toward an inverse relation of approaches to crossings has been found in the other studies on drives with the Obstruction Apparatus. The reason the number of approaches is larger for the delayed group which crosses fewer times is that the control group was probably affected by the incentive in such a manner that

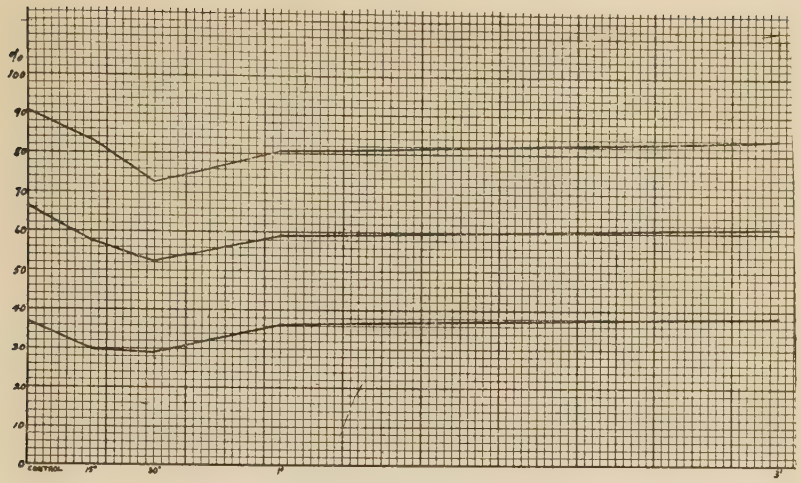

FIGURE 3

TEMPORAL DISTRIBUTION OF CROSSINGS FOR THE COMBINED (MALE AND FEMALE) GROUPS

The lower line represents the percentage of crossing which occurred during the first 5 minutes of the test period. The middle line represents the percentage which occurred during the first 10 minutes. The upper line represents the percentage which occurred during the first 15 minutes.

activity in the direction of the incentive compartment nearly always resulted in the full response of crossing, while the conditions of delay resulted in the activity's taking the less complete form of approaching. Stated in terms of drive, the hunger drive was decreased by the conditions of delay, or the incentive value was not great enough to elicit the complete response of crossing the grid so often.

The scores on average contacts were not materially different under conditions of delay than under the normal incentive situation, indicating that the delay did not influence significantly partial crossings.

The scores on average crossings for the 30-second and 1-minute groups are only slightly different from those of the 15-second group. The differences may perhaps be regarded as fluctuations due to chance factors, so that we may conclude that there is little difference between the effects of 15-second, 30-second, and 1-minute delays. The scores on average approaches and contacts tend to support this conclusion.

However, there is a decided drop in average crossings with the 3-minute group, an animal delayed for this length of time crossing on an average of only about 4 times as compared with 10 for the smaller periods of delay and 17 for the 0-delay group. This indicates a marked decrease in drive with delays as long as 3 minutes. There is some indication that the animals in the 3-minute group were less active than the other groups, since the number of approaches did not increase appreciably with the further decrease in crossings and the number of contacts actually decreased slightly. The incentive value was evidently so weak under this long delay that there was elicited less general activity (approaches and contacts), since an increased number of approaches might have been expected with decrease in number of crossings.

The difference between the average crossings of the control group and each of the delay groups (Table 7) is in all cases very reliable. We find a tendency for the reliability to increase as the period of delay increases in length. There is also a tendency for the reliability of the difference between the groups to increase as the difference betwen periods of delay increases. Thus,

when we compare delay groups in which the difference in length of period of delay is relatively small, as in comparisons between the 15-second, 30-second, and 1-minute groups, little reliability is found. This supports our conclusion that there is little difference in effect between delays of 15 seconds, 30 seconds, and 1 minute. In delay groups in which the difference in length of the periods of delay is relatively large, as in the comparisons between the 3-minute group and the other delay groups, we find that the differences are highly reliable. Hence the drop in the curve with the 3-minute group seems to represent a genuine tendency.

TABLE 7

RELIABILITY OF THE DIFFERENCES BETWEEN THE AVERAGE CROSSINGS OF EACH GROUP

Groups	Difference	S. D. of the difference	Difference / S. D. of the difference	Chances in 100 of a true difference greater than 0
0 and 15 Sec.	7.6	2.03	3.74	100
0 and 30 Sec.	9.3	2.23	4.17	100
0 and 1 Min.	8.3	2.10	3.95	100
0 and 3 Min.	12.9	1.95	6.62	100
15 Sec. and 30 Sec.	1.7	1.74	.98	84
15 Sec. and 1 Min.	.7	1.57	.45	67
30 Sec. and 1 Min.	1.0	1.82	.55	71
15 Sec. and 3 Min.	5.3	1.37	3.87	100
30 Sec. and 3 Min.	3.6	1.66	2.17	98.6
1 Min. and 3 Min.	4.6	1.44	3.19	100

There is little evidence of sex differences from the scores on average crossings (Table 6) with the exception of one group. In the case of the 30-second group, the average of the females is considerably lower than

TABLE 8

Temporal Distribution of Approaches, Contacts, and Crossings during the 20-Minute Test Period in 1-Minute Intervals

Delay period	Activity	1st Min.	2nd Min.	3rd Min.	4th Min.	5th Min.	6th Min.	7th Min.	8th Min.	9th Min.	10th Min.	11th Min.	12th Min.	13th Min.	14th Min.	15th Min.	16th Min.	17th Min.	18th Min.	19th Min.	20th Min.
0	Approaches	7	2	4	1	3	2	0	3	1	2	4	2	8	2	2	4	4	4	7	3
	Contacts	4	3	3	3	3	6	3	4	7	3	7	9	15	7	4	5	5	8	12	7
	Crossings	29	34	19	14	34	30	22	24	18	8	11	23	26	10	16	13	7	9	3	1
15 Sec.	Approaches	20	27	19	30	26	17	17	20	19	24	16	18	24	17	8	9	8	15	15	14
	Contacts	7	9	7	10	12	12	3	5	6	7	5	9	4	4	1	2	10	4	5	5
	Crossings	14	12	11	15	8	14	9	8	11	14	13	8	8	10	12	3	7	8	5	10
30 Sec.	Approaches	33	17	22	25	29	22	37	24	17	30	30	19	18	21	17	16	19	10	11	18
	Contacts	10	8	9	12	9	8	6	12	2	2	9	2	2	5	3	3	2	0	2	3
	Crossings	15	9	12	4	8	7	6	11	7	7	6	9	5	8	6	9	8	10	9	9
1 Min.	Approaches	18	27	14	17	14	18	12	31	18	18	14	12	17	13	11	16	15	18	13	20
	Contacts	3	8	5	7	5	1	6	7	4	2	4	4	6	4	5	7	4	5	9	9
	Crossings	18	12	13	11	13	8	8	8	8	11	5	9	10	6	9	8	7	5	7	9
3 Min.	Approaches	25	23	26	8	16	13	11	18	24	27	22	17	17	21	16	16	13	17	13	23
	Contacts	10	4	13	7	0	4	1	2	6	3	2	2	0	1	2	0	2	0	1	0
	Crossings	13	5	8	4	6	3	5	4	6	3	5	3	3	6	5	4	5	1	3	2

TABLE 9

TEMPORAL DISTRIBUTION OF APPROACHES, CONTACTS, AND CROSSINGS DURING THE 20-MINUTE TEST PERIOD IN 5-MINUTE INTERVALS

Delay period	Activity	0 -5th Minute		6th-10th Minute		11th-15th Minute		16th-20th Minute		Total
		Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
0	Approaches	17	26.2	8	12.6	18	27.6	22	33.8	65
	Contacts	16	13.5	23	19.5	42	35.5	37	31.4	118
	Crossings	130	37.0	102	29.1	86	24.5	33	9.4	351
15 Sec.	Approaches	122	33.6	97	26.7	83	22.9	61	16.8	363
	Contacts	45	35.4	33	26.0	23	18.1	26	20.5	127
	Crossings	60	30.0	56	28.0	51	25.5	33	16.5	200
30 Sec.	Approaches	126	29.0	130	29.9	105	24.1	74	17.0	435
	Contacts	48	44.0	30	27.5	21	19.3	10	9.2	109
	Crossings	48	29.1	38	23.0	34	20.6	45	27.3	165
1 Min.	Approaches	90	26.8	97	28.9	67	20.0	82	24.4	336
	Contacts	28	26.7	20	19.0	23	21.9	34	32.4	105
	Crossings	67	36.2	43	23.2	39	21.1	36	19.5	185
3 Min.	Approaches	98	26.8	93	25.4	93	25.4	82	22.4	366
	Contacts	34	56.6	16	26.7	7	11.7	3	5.0	60
	Crossings	36	38.3	21	22.3	22	23.4	15	16.0	94

that for the males. Reference to Table 5 shows that there were three females in the 30-second group which crossed only once. This is an unusually large percentage of animals with only one crossing, in view of the high average score. The notes on behavior indicate nothing unusual in the behavior of these animals. Their general behavior was perfectly normal and they were quite active in exploring the entrance compartment. This apparent sex difference for the 30-second group would seem to be due to some accidental factor rather than to a genuine difference between the sexes. At any rate, the other three groups show no such differences so that no consistent sex differences can be claimed as resulting from the delayed incentive factor.

Tables 8 and 9, which show the temporal distribu-

tion of approaches, contacts, and crossings during the 20-minute test period, and Figure 3, showing crossings, do not reveal any significant differences between the control group, which may be called the "normal" incentive group, and the delayed incentive groups. Table 9 and Figure 3 indicate that the approaches, contacts, and crossings occurred rather uniformly throughout the 20-minute period for all of the groups. That is, delay apparently had no effect in bringing about a change in the relative number of crossings, contacts, and approaches during the early or later stages of the test.

C. Summary of Results

1) The hunger drive, as measured by the Obstruction Method, was markedly decreased by a period of delay as short as 15 seconds between the crossing of the grid and the obtaining of the incentive (43 per cent decrease in number of crossings).

2) Longer delay periods of 30 seconds and 1 minute did not further decrease the drive index.

3) A period of delay as long as 3 minutes effected a further marked decrease in number of crossings (73 per cent from control group).

4) The data on approaches and contacts corroborated the conclusions based on crossings. The effect of delay tended to increase the number of approaches as would be expected since the number of crossings was decreased. The number of contacts remained approximately the same for all the groups.

III

EXPERIMENT 2

THE LEARNING METHOD

A. Method and Procedure

Apparatus. The apparatus used with the learning method of studying delay was the standard unit maze designed by Warner and Warden (13). Figure 4 shows the types of unit of which the maze is constructed. The material used in building the maze was 18-gauge, galvanized, Armco sheet metal covered with aluminum paint to insure uniformity of appearance. As is seen in the figure, the units consist of walls and a roof, with no floor. They were set up on a platform 7 x 8 feet in size, which had been covered, after very smooth finishing, with battleship linoleum (cemented down). This platform served as a base or floor. The angle of junction of cul-de-sac to pathway is the same as the angle at the end of the cul-de-sac, so that the animal can get no cues from looking down into the latter as to whether it is a blind alley or not. The roof of both pathway unit and cul-de-sac is made of very heavy wire mesh neatly riveted into the frame, while the two ends of the cul-de-sac are also made of wire mesh in order to secure lighting conditions in the alley similar to those of the pathway.

Several problems arose in connection with the apparatus. The first concerned the pattern to be used

FIGURE 4

PHOTOGRAPH SHOWING TYPES OF UNIT OF THE WARNER-WARDEN STANDARD UNIT MAZE

in the present study. It was desired that the pattern be sufficiently difficult to bring out individual and group differences and yet simple enough to be learned in a reasonable time. The pattern finally chosen (Figure 5) met these requirements very well. The conditions of the study made the use of a screen and peephole impossible for practical purposes, since the noiseless operation of the doors was especially important. Great care was needed to prevent the animal from becoming conditioned against the restraining compartment, and one of the most common causes of fear in experiments with rats is the matter of occasionally pinching their tails in the doors of an apparatus. Automatically controlled doors were impractical and doors operated by a system of levers and strings proved to be too slow for the rat's quick movements. In many animal mazes the entrance and food boxes are a considerable distance from each other, necessitating the use of two experimenters, one to introduce the animal and the other to remove it, or else the experimenter must change his position during a given trial. In the pattern used, the entrance and food boxes were in close

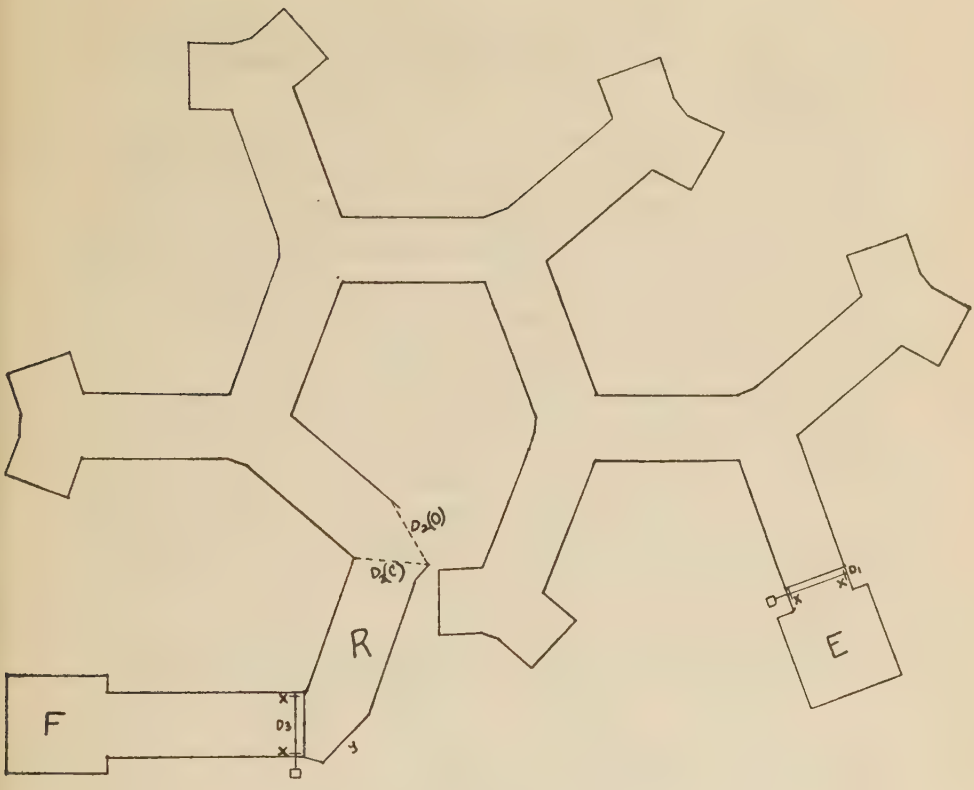

FIGURE 5

MAZE PATTERN

E, entrance compartment; *F*, food box; *R*, restraining compartment; d_1, door separating entrance compartment from maze; d_2, door separating restraining compartment from maze; *o* and *c* represent door (d_2) in open and closed positions, respectively; d_3, door separating restraining compartment from food box; *xx*, rubber washers on brass rod to which door is fastened; *y*, piece of thin metal used to close opening in *R*.

proximity to each other, making the change of position of the experimenter unnecessary. The experimenter took a position midway between the two boxes

and remained quietly throughout a given trial operating manually the doors for both the entrance and the food boxes.

The fact that the pathways were somewhat deeper than those of most rat mazes (5 inches in the clear), together with the fact that a wire mesh was used as a covering for the maze, aided in the elimination of the experimenter from the visual field of the animal. A stop-watch of the lever type was used in the experiment and proved to be practically noiseless.

Several slight modifications were made in the apparatus as described by Warner and Warden (13). In previous work with this maze in the Columbia laboratory it was found that the animals hesitated as if frightened upon coming from the covered pathways into the food box, which was not covered with wire mesh. To prevent this behavior, a piece of mesh, of the same size as that forming the roof of the pathway and cul-de-sac units, was fastened over the long, narrow portion of the food box, so that the latter would more nearly resemble the other parts of the maze. A thin metal door (Figure 5, d_1, d_3) of the swinging type replaced the heavier metal sliding door at both the entrance and food compartments. The door, in each case, was fastened to a brass rod which turned in holes in the sides of the unit. Rubber washers (xx) prevented any noise which might result from the rod turning on the metal, and felt fastened to the bottom of the doors made their operation practically noiseless.

The problem of restraining the animal from the food during the delay period was met by using a pathway

unit as a restraining compartment (R). This was placed between the last pathway unit of the pattern and the food box. Since this involved joining a pathway unit with another pathway unit instead of a cul-de-sac, as in the ordinary maze pattern, two openings were left in the restraining compartment. The opening nearest the food box was closed up by a thin piece of metal (y) especially cut to fit it. The other opening was used to good advantage. A thin metal door (d_2) of the swinging type with vertical pivot was made and served two purposes. When it was open it formed the wall of the maze between the last pathway unit and the restraining compartment; when closed, it served to prevent the animal from retracing its steps into the maze, thus forming an effective restraining compartment. A wire hook attached to the door provided a secure fastening. The door (d_3) to the food box was held closed by a brass stop while the animal was in the restraining compartment.

A piece of plate glass was used, to cover that part of the food box in which the food was placed, to prevent the animals from climbing out during the allotted time for feeding. The experimenter soon developed a noiseless method for replacing and removing this glass.

Animals. The subjects for this experiment were 105 male albino rats of approximately 100 grams in weight and 2 months of age at the beginning of the experiment, obtained from the Albino Supply Inc., of Philadelphia. Upon arrival at our laboratory, the animals were placed in large cages, 30 x 15 x 15 inches, about 12-15 animals to a cage, and kept for two

weeks before they were used. This two-week period previous to testing enabled them to become accustomed to laboratory conditions and to the experimenter, who handled them daily in feeding. All the animals remained in normal health throughout the experiment.

The animals were fed whole-wheat bread and milk throughout the experiment, with the addition of a weekly ration of greens. This diet was chosen instead of McCollum's Standard Diet because of the high incentive value of bread and milk (6). The animals were given their ration after the daily trial in the maze, the same food being used both for incentive and for regular feedings. Fresh water was supplied daily from inverted bottles with nozzles to prevent fouling. The animals were supplied with water even during the 24-hour starvation period. Before the starvation period, which marked the beginning of the experiment, fresh sawdust was supplied to insure complete absence of any food in the cage.

Five groups of animals were used. Table 10 shows the number of animals in each group. In addition to the 0-delay, or control group, four groups were used with the following intervals of delay: 1 minute, 3 minutes, 5 minutes, and 7 minutes.

The starvation period was 24 hours for all groups. The number of trials per day was constant for the groups, only one trial per day being given to each animal.

Procedure. The sex drive was kept constant for all groups by using males. It seemed advisable to eliminate all oestrous cycle complications by this restriction

TABLE 10

GROUPING OF ANIMALS

Length of delay period	No. of animals
0 (Control)	16
1 Minute	22
3 Minutes	22
5 Minutes	20
7 Minutes	25

in the interests of a more adequate control of extraneous drive conditions. They were segregated as to sex during the two weeks previous to the beginning of the experiment and throughout the period of learning. The factor of time of day was controlled by running all the animals between the hours of 9 P.M and 4 A.M. Since the laboratory was practically deserted at this time, noise distractions were reduced to a minimum. The room in which the experiment was conducted was lighted indirectly by electric light, the same number of lamps being lighted each night. The illumination was thus uniform in all parts of the room. The maze was kept in a constant position in the room throughout the experiment and care was taken not to shift the pattern to new positions on the platform. The temperature was kept fairly constant by means of a thermostat.

The preliminary training consisted in feeding each animal singly in the entrance and food compartments 1 minute each and in a small feeding cage nearby for 10 minutes thereafter. A glass plate was kept on the food box to prevent the animal from climbing out during the 1-minute feeding period. This preliminary feeding was given the animals for two days. The animals were starved for 24 hours before each feeding

period, as during the training series. The first trial, which occurred on the third day, was included in the preliminary training. The arguments for this procedure, which is the rule in the Columbia laboratory, have been developed by Cook (2).

The procedure for the 0-delay, or control group, was that usually employed in maze experiments, except that the animal was fed for a period of 1 minute in the food box and for 9 minutes in an adjacent feeding cage after the daily trial. The door between the maze proper and the restraining compartment (Figure 5, d_2) was open when the rat was placed in the maze. The stop-watch was started at the same time the animal was inserted in the maze. When the animal's tail cleared the door (d_2) at the restraining compartment, the door was closed and the watch stopped. The door (d_3) between the restraining compartment and the food box was raised immediately, allowing the animal to pass to the food box, and then closed. d_3 was raised, since this procedure was necessary in the case of the delay groups. The watch was started again, when d_3 was closed, to time the 1-minute feeding period in the food box. After the animal had fed for 1 minute, it was removed to the adjacent feeding cage and allowed to remain for 9 minutes.

The procedure for the delay groups was the same as that for the control group, with the following exception: Upon entering the restraining compartment, the animal was delayed for a period of time (1 minute, 3 minutes, 5 minutes, or 7 minutes) by closing the door (d_2) behind it. After the period of delay was over,

the animal was permitted to enter the food box through d_3, which was raised, as in the control group.

Data were taken in terms of trials, errors, and time in seconds. An error was checked when the animal's nose projected past the entrance to a cul-de-sac. This criterion of error was chosen because the entrance of the nose in a cul-de-sac was more easily observed, and hence could be more accurately checked than other possible movements of the animal. Backward errors were checked for each unit of the pathway. Notes were made on the general activity of the animals in the delay compartment during the period of delay.

A change in the procedure was introduced at the 100th trial in the case of those animals which had not learned after running 99 trials and which had shown no indication of learning for 50 trials. On the 100th trial and thereafter, these animals were allowed immediate access to the food box, as in the case of the control group. This change was introduced to ascertain whether these animals were lacking in ability to learn the maze or whether failure to learn up to that time was due to the factor of delay.

The animals were run until they had attained the norm of mastery of four perfect trials out of five (Norm B), except the nine animals which had not reached the norm at the 99th trial. The data were also computed on the basis of the norm of two perfect trials out of three (Norm A), and under this norm all of the animals had learned by the 99th trial. In computation of scores the last four trials involved in the norm of mastery were omitted.

B. Results

The main results are based on the scores obtained by using the norm of two perfect trials out of three (Norm A) for the reason that only under this norm did all animals complete the learning process. The scores obtained under Norm B will be treated in a later section.

Norm A. The results are presented in Tables 11, 12, 13, 14, 15, 16, and 17, and in Figures 6, 7, and 8. Table 11 gives the frequency distributions covering trials, errors, and time for the various groups. Beginning at the fourth line, it reads as follows: one animal in the 0-delay group, one in the 1-minute group, and one in the 3-minute group, none in the 5-minute, and one in the 7-minute group learned in four trials. Two animals in the 0-delay group and none in any of the other groups made between 13 and 16 errors in learning. Four animals in the 0-delay group, one in the 1-minute group, none in the 3-minute group, one in the 5-minute group, and none in the 7-minute group required from 91 to 120 seconds to learn, etc. Table 12 gives the frequency distributions covering trials, errors, and time for the various groups, using larger intervals (1-5 for trials, 1-15 for errors, 1-150 for seconds). Table 13 is a cumulative frequency table showing percentage of group having learned by the end of each successive five trials. Figure 6 shows the same thing in graphic form. Table 14 presents the measures of central tendency and measures of variability for each period of delay. Table 15 gives the measure of reliability of the difference between the averages

of various groups for trials, errors, and time. Table 16 gives the average errors per trial for each five trials. Figure 7 shows the same thing graphically. Table 17

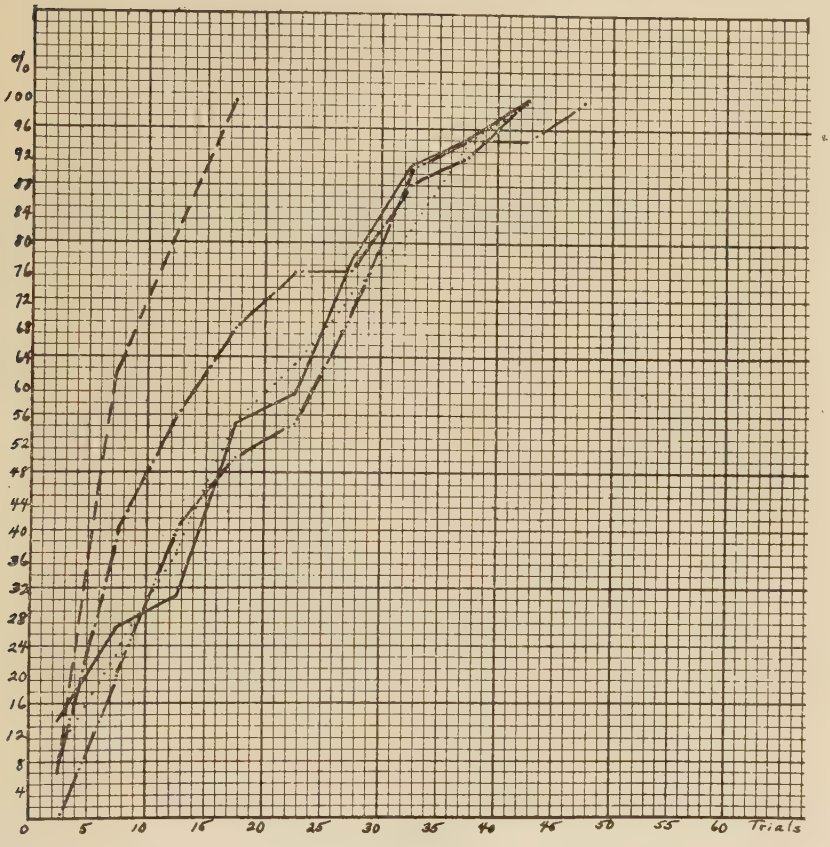

FIGURE 6

CUMULATIVE FREQUENCY CURVES SHOWING PERCENTAGE OF GROUP HAVING LEARNED BY THE END OF EACH SUCCESSIVE FIVE TRIALS (NORM A)

Control group (dash-line); 1-minute group (solid line); 3-minute group (dot line); 5-minute group (dot-dot-dash line); 7-minute group (dot-dash line).

TABLE 11

FREQUENCY DISTRIBUTIONS COVERING TRIALS, ERRORS, AND TIME FOR THE VARIOUS GROUPS (NORM A)*

No. of trials	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.	No. of errors	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.	No. of seconds	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.
1						1-4						1-30					
2						8						60		1			1
3		1				12					1	90	6	1	1		1
4	1	1	1		1	16	2					120	4	1		1	
5		1	1		1	20	1	1			2	150	1	4	2	2	3
6	3			3	1	24	3	1	1	1	3	180	1	1		2	2
7	2		1		3	28	2	1	2		1	210	2	1	3		2
8		1	1		1	32	1	1	1	2	1	240	1	3	3		2
9	2	2	1		3	36	1			1	2	270	1	1	1	1	
10	2			1		40	2	3	1	1		300		1			2
11			1		2	44			2		1	330			2	1	2
12	3		2			48			2	1	2	360		2		2	2
13				2	1	52		2			1	390		1	2	1	1
14		1		1	1	56	1	1	1	1	2	420		2		3	
15				1		60		1				450			1		1
16		2	1	1		64	2	3	2			480			1		
17	1	1	1		1	68					2	510		1			
18	1	1	1	1	1	72	1	1		1		540			1		
19	1		1		1	76			1	1		570				1	
20		1				80		1		1		600					
21		1	1			84		1		3	1	630			2	1	
22					1	88			1		1	660		1	1		
23			1		1	92				1	1	690				2	
24				1		96			2			720					
25						100		1	2			750			1	1	
26		1		1		104		1	1			780		1			1
27			1	1		108						810					1

No. of trials	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.	No. of errors	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.	No. of seconds	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.
28				1		112			1	3		840				1	2
29		2				116		1		1		870					
30		1	1			120					1	900					1
31		1	1		1	124		1	2	1		930					
32		1	1		1	128						960					
33		1		1		132						990				1	
34				1	1	136		1			1	1020					
35				2		140						1050					
36		1	1		1	144						1080			1		
37			2	1		148						1110					
38						152						1140					
39						156				1	1	1170					
40						160						1200					
41					1	164						1230					
42		1				168						1260					
43						172					1	1290					1
44					1	176						1320					
45			1			180						1350					
46						184						1380					
47				1		188						1410					
48						192						1440					
49						196						1470					
50						200						1500					

*Two perfect trials out of three.

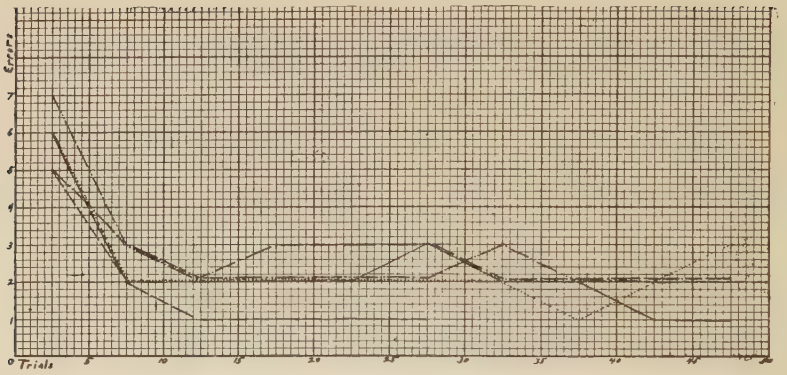

FIGURE 7

AVERAGE ERRORS PER TRIAL FOR EACH FIVE TRIALS

Control group (dash line); 1-minute group (solid line); 3-minute group (dot line); 5-minute group (dot-dot-dash line); and 7-minute group (dot-dash line).

presents the average time per trial for each five trials. Figure 8 gives the same data in graphic form.

When we examine the averages for the groups based on the scores for trials (Table 14), we note that the averages and medians of the delayed incentive groups are considerably higher than those of the control group. It will be seen from the table that the effect of a 1-minute delay is practically to double the number of trials required to learn the maze. The difference between the averages of the 1-minute group and the control group is highly reliable (3.82), as is shown in Table 15. The scores on errors and time show very much the same tendency.

The scores on trials and errors for the 3-minute, 5-minute, and 7-minute groups are only slightly different from those of the 1-minute group (Table 14), and in no case is the difference very reliable (the range in re-

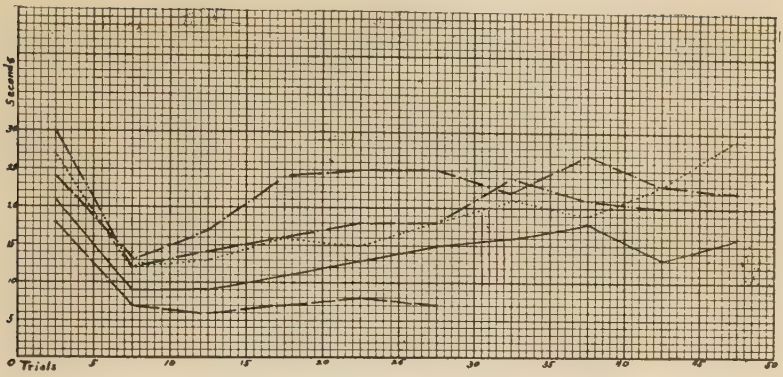

FIGURE 8

AVERAGE TIME PER TRIAL FOR EACH FIVE TRIALS

Control group (dash line); 1-minute group (solid line), 3-minute group (dot line); 5-minute group (dot-dot-dash line); and 7-minute group (dot-dash line).

liability index is .12 to 1.44), as will be seen from Table 15. This means that there is little difference between the effects of 1-minute, 3-minute, 5-minute, and 7-minute delays when trial and error scores are considered.

The error curves (Figure 7) indicate that the animals in the delayed incentive groups did not differ markedly from each other in errors per trial. They consistently made more errors than the control-group animals. Thus, these results corroborate our conclusions based on scores for trials and for errors.

In the case of the time scores, however, the averages tend to increase with increase in length of delay period. The differences between the averages also tend to be slightly more reliable (the range in reliability is .12 to 2.26), as is shown in Table 15. In general, time scores are not considered as valid an index of learning

TABLE 12

FREQUENCY DISTRIBUTIONS COVERING TRIALS, ERRORS, AND TIME FOR THE VARIOUS GROUPS (NORM A)*

No. of trials	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.	No. of errors	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.	No. of seconds	Groups 0	1 Min.	3 Min.	5 Min.	7 Min.
1-5	1	3	2	0	2	1-15	2	0	0	0	1	1-150	11	7	3	3	5
10	9	3	3	4	8	30	7	4	4	1	7	300	5	7	8	3	8
15	3	1	3	4	4	45	3	3	5	5	5	450		5	4	7	6
20	3	5	4	2	3	60	1	4	1	1	3	600		1	2	1	0
25		1	2	1	2	75	3	4	3	2	2	750		1	4	4	0
30		4	2	3	0	90		2	1	5	2	900		1	0	1	5
35		3	2	4	3	105		2	5	0	1	1050			0	1	0
40		1	3	1	1	120		1	1	4	1	1200			1		0
45		1	1	0	2	135		2	2	1	1	1350					1
50				1		150				0	0						
						165				1	1						
						180					1						

*Two perfect trials out of three.

TABLE 13

CUMULATIVE FREQUENCY TABLE SHOWING PERCENTAGE OF GROUP HAVING LEARNED BY THE END OF EACH SUCCESSIVE FIVE TRIALS (NORM A)*

No. of trials	Groups				
	Control	1 Min.	3 Min.	5 Min.	7 Min.
1-5	6.3	13.6	9.1	0.0	8.0
10	62.5	27.3	22.7	20.0	40.0
15	81.3	31.8	36.4	40.0	56.0
20	100.0	54.5	54.5	50.0	68.0
25		59.1	63.6	55.0	76.0
30		77.3	72.7	70.0	76.0
35		90.9	81.8	90.0	88.0
40		95.5	95.5	95.0	92.0
45		100.0	100.0	95.0	100.0
50				100.0	

*Two perfect trials out of three.

in maze experiments as trial and error scores, and hence more weight will be given to the latter. The inconsistency of the time scores with the general tendency of similarity among the delay groups seems to indicate that the longer delays caused the animals to run more leisurely through the maze. The lengthened time score arising in connection with delay is supported by behavior observations made by the experimenter. The animals appeared to be less motivated and ran slowly through the maze in a hesitant manner, while the control-group animals ran more quickly and directly through the maze to the food box. The time curves (Figure 8) show this same tendency—increase in time per trial with increase in length of delay period. The 7-minute group curve strikingly illustrates this tendency, rising much more suddenly than the other curves and remaining at a higher level. Thus the animals in the delay groups took a longer time per trial with increase of length of delay period.

TABLE 14
RESULTS FOR EACH PERIOD OF DELAY (NORM A)*

Period of delay	Trials					Errors					Time				
	Median	Range	Aver.	S.D.	V.	Median	Range	Aver.	S.D.	V.	Median	Range	Aver.	S.D.	V.
0	9.5	4-19	10.3	4.40	42.72	29.0	13- 71	34.8	17.53	50.37	109.0	75- 258	131.0	54.44	41.56
1 Minute	19.0	3-42	20.3	11.14	54.88	60.5	17-135	64.3	32.12	49.95	237.0	49- 772	278.3	177.95	63.94
3 Minute	18.5	4-45	20.7	11.76	56.81	62.0	21-124	68.5	32.61	47.61	318.0	83-1061	380.4	234.99	61.77
5 Minute	21.0	6-47	22.2	11.77	53.02	80.5	31-154	77.1	35.22	45.68	381.0	106- 988	428.5	244.41	57.04
7 Minute	13.0	4-44	17.5	11.94	68.23	45.0	9-171	60.2	43.36	72.03	293.0	57-1288	390.0	310.02	79.49

*Two perfect trials out of three.

TABLE 15

RELIABILITY OF THE DIFFERENCE BETWEEN THE AVERAGES OF THE VARIOUS GROUPS (NORM A)*

Groups	Trials				Errors				Time			
	Difference	S.D. of the difference	Difference / S.D. of the difference	Chances in 100 of a true difference greater than 0	Difference	S.D. of the difference	Difference / S.D. of the difference	Chances in 100 of a true difference greater than 0	Difference	S.D. of the difference	Difference / S.D. of the difference	Chances in 100 of a true difference greater than 0
0 and 1 Min.	10.0	2.62	3.82	100	29.5	8.13	3.63	100	147.3	40.31	3.65	100
0 and 3 Min.	10.4	2.74	3.80	100	33.7	8.22	4.10	100	249.4	51.92	4.80	100
0 and 5 Min.	11.9	2.85	4.18	100	42.3	9.02	4.69	100	297.5	56.35	5.28	100
0 and 7 Min.	7.2	2.63	2.74	99.7	25.4	9.71	2.62	94	259.0	63.47	4.08	100
1 Min. and 3 Min.	.4	3.45	.12	55	4.2	9.76	.43	66	102.1	62.84	1.62	94
1 Min. and 5 Min.	1.9	3.46	.55	71	12.8	10.44	1.23	89	150.2	66.55	2.26	98.9
1 Min. and 7 Min.	2.8	3.37	.83	80	4.1	11.05	.37	64	111.7	72.69	1.54	93
3 Min. and 5 Min.	1.5	3.64	.41	65	8.6	10.52	.82	79	48.1	74.16	.65	74
3 Min. and 7 Min.	3.2	3.47	.92	82	8.3	11.11	.75	77	9.6	79.71	.12	54
5 Min. and 7 Min.	4.7	3.55	1.32	90	16.9	11.72	1.44	93	38.5	82.67	.47	67

*Two perfect trials out of three.

TABLE 16*

AVERAGE ERRORS PER TRIAL FOR EACH FIVE TRIALS

No. of trials	Groups				
	Control	1 Min.	3 Min.	5 Min.	7 Min.
1-5	5	6	6	7	5
10	2	2	2	3	3
15	1	2	2	2	2
20	1	2	2	2	3
25	1	2	2	2	3
30	1	3	2	2	3
35		2	2	3	2
40		2	1	2	2
45		1	2	2	2
50		1	3	2	2

*In most learning experiments it is not possible to obtain an adequate picture of the average time per trial or of the average errors per trial for any group, due to the fact that individual animals reach the norm of mastery after different numbers of trials and are dropped out of the experiment. Thus the latter part of the curve must be based on smaller and smaller numbers of animals. In our experiment, however, we continued to run the animals in an effort to have them reach the higher norm (Norm B). We, therefore, had data on a large number of animals beyond the point where they had learned under the lower norm (Norm A), and in constructing our tables (16, 17) and curves (Figures 7, 8) for time and errors per trial, we used this available data so as to increase the validity of the latter part of the curve by the resulting increase in number of animals making up the average at a given point. This method probably gives a closer approximation to a true curve than possible statistical methods. The exact number of animals upon which the average at any point is based may be ascertained by reference to Figure 11.

TABLE 17

AVERAGE TIME PER TRIAL FOR EACH FIVE TRIALS

No.of trials	Groups				
	Control	1 Min.	3 Min.	5 Min.	7 Min.
1-5	18	21	27	30	24
10	7	9	12	12	13
15	6	9	13	14	17
20	7	11	16	16	24
25	8	13	15	18	25
30	7	15	18	18	25
35		16	21	24	22
40		18	19	21	27
45		13	23	20	23
50		16	29	20	22

The notes made on the behavior of the animals in the delay compartment reveal no noticeable differences

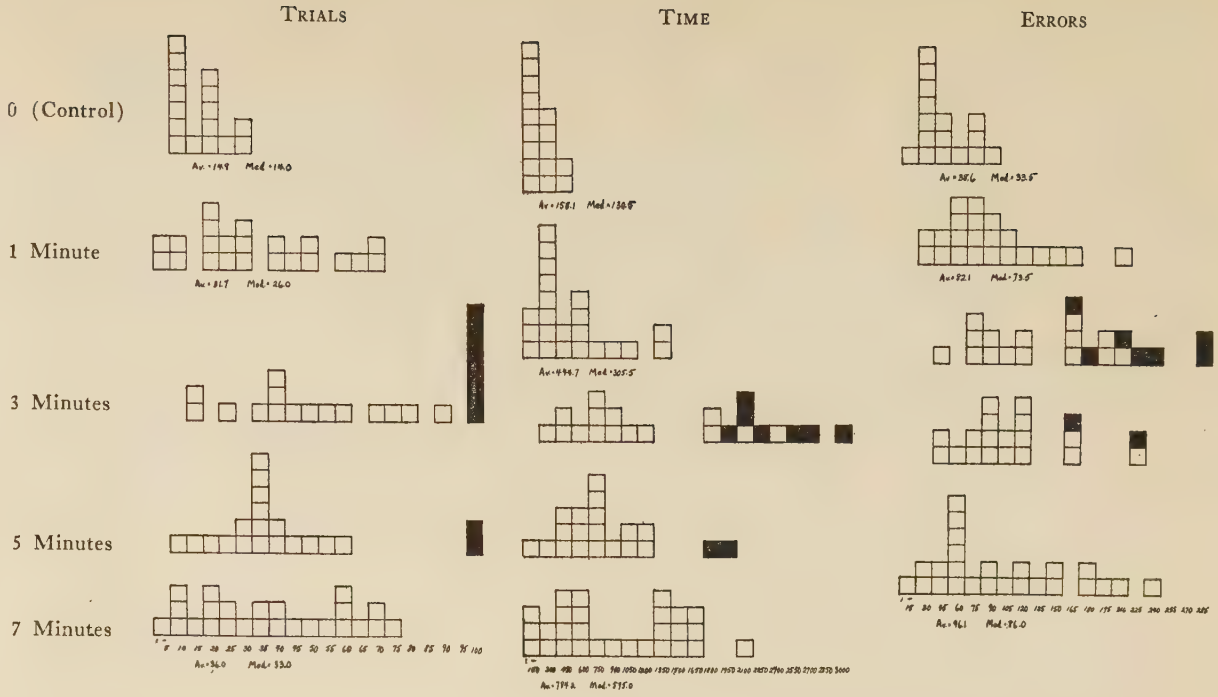

FIGURE 9

DISTRIBUTION OF ANIMALS ACCORDING TO TRIALS, ERRORS, AND TIME TAKEN TO LEARN (NORM B)

Each square represents one animal

between the groups. All animals were equally active, running back and forth, biting and clawing at the doors, etc. In no case did an animal remain quiescent or merely wait for the door to be opened. When released from the compartment, the animals in all cases ran directly to the food and ate for the full minute allowed them in the food box, except on the first few trials during which they exhibited the usual exploratory activity which is natural for the rat in a relatively new situation.

Norm B. An attempt was made to run all of the animals until they attained the norm of four perfect trials out of five. Since 9 animals had not reached the norm at the 99th trial, and had shown no indication of learning for 50 trials, the change in conditions from delayed to immediate incentive was introduced. The effect of this change will be discussed in this section.

The results are presented in Tables 18, 19, and 20 and in Figures 9, 10, 11, and 12.

Figure 9 presents the distribution of animals according to trials, errors, and time taken to learn, each square representing one animal. The animals which had not learned by the 99th trial are indicated in solid black.

Table 18 is a cumulative frequency table showing percentage of group having learned by the end of each successive five trials. Figure 10 presents the data in graphic form.

Table 19 shows the effect of change in procedure from delayed to immediate incentive conditions, in terms of average time per trial, on the 9 animals which had not reached Norm B by the 99th trial. Figure 11 shows the same thing in graphic form.

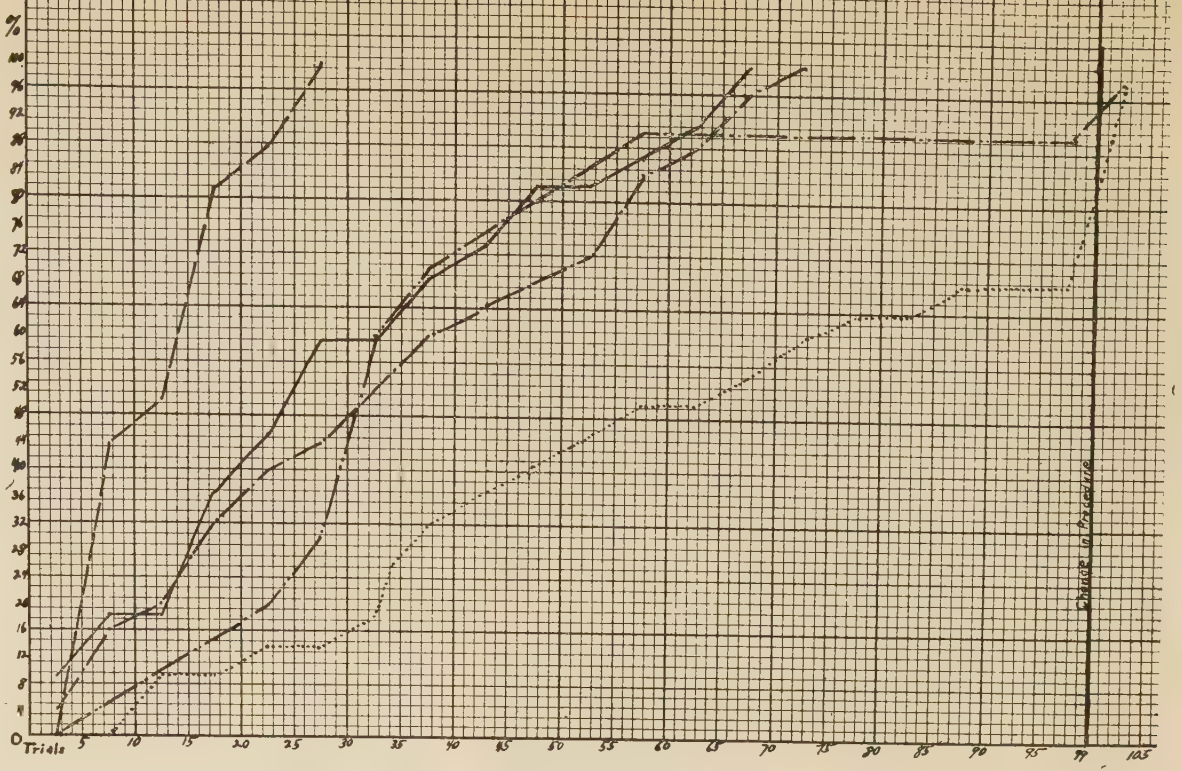

FIGURE 10

CUMULATIVE FREQUENCY CURVES SHOWING PERCENTAGE OF GROUP HAVING LEARNED BY THE END OF EACH SUCCESSIVE FIVE TRIALS (NORM B)

Control group (dash line); 1-minute group (solid line); 3-minute group (dot line); 5-minute group (dot-dot-dash line); 7-minute group (dot-dash line).

FIGURE 11

EFFECT OF CHANGE IN PROCEDURE FROM DELAYED INCENTIVE TO IMMEDIATE INCENTIVE CONDITIONS IN TERMS OF AVERAGE TIME PER TRIAL

Table 20 shows the effect of change in procedure from delayed to immediate incentive conditions, in terms of average errors per trial, on the 9 animals which had not reached Norm B by the 99th trial. Figure 12 shows the same data graphically.

We note from Figure 9 that 9 of the animals failed to learn, under this norm, in 99 trials. Obviously true averages and medians could not be obtained for the groups in which these animals occurred (3-minute and 5-minute groups). The averages and medians of the

TABLE 18

CUMULATIVE FREQUENCY TABLE SHOWING PERCENTAGE OF GROUP HAVING LEARNED BY THE END OF EACH SUCCESSIVE FIVE TRIALS (NORM B)*

No. of trials	Groups				
	Control	1 Min.	3 Min.	5 Min.	7 Min.
1-5	0.0	9.1	0.0	0.0	4.0
10	43.8	18.2	0.0	5.0	16.0
15	50.0	18.2	9.1	10.0	20.0
20	81.3	36.4	9.1	15.0	32.0
25	87.5	45.5	13.6	20.0	40.0
30	100.0	59.1	13.6	30.0	44.0
35		59.1	18.2	60.0	52.0
40		68.2	31.8	70.0	60.0
45		72.7	36.4	75.0	64.0
50		81.8	40.9	80.0	68.0
55		81.8	45.5	85.0	72.0
60		86.4	50.0	90.0	84.0
65		90.9	50.0	90.0	88.0
70		100.0	54.5	90.0	96.0
75			59.1	90.0	100.0
80			63.6	90.0	
85			63.6	90.0	
90			68.2	90.0	
95			68.2	90.0	
99			68.2	90.0	
	Change to immediate incentive conditions				
105			100.0	100.0	

*Four perfect trials out of five.

remaining groups are indicated in Figure 9. It will be seen from the distributions according to trials, errors, and time (Figure 9) that the delay groups all learned more slowly than the control group, showing the same general tendency as under Norm A. It appeared to be of some interest to see what would happen, under conditions of immediate feeding, to the 9 animals which had not learned. Accordingly, on the 100th trial and thereafter the interval of delay between running the maze and being fed was eliminated and the animals were allowed to proceed at once into the food box, as in the case of the control group. Although

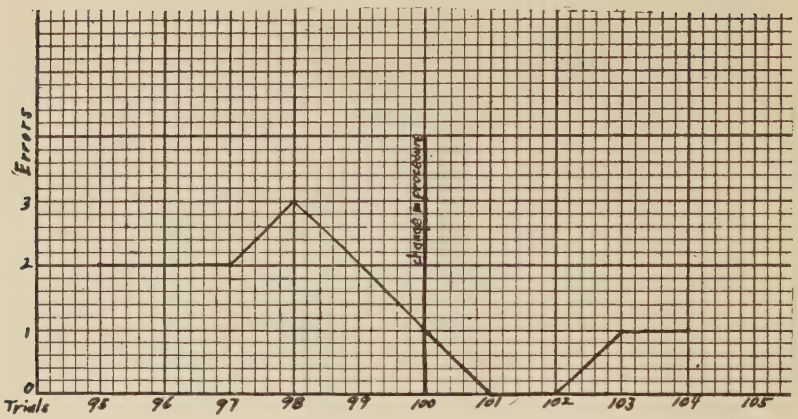

FIGURE 12

EFFECT OF CHANGE IN PROCEDURE FROM DELAYED TO IMMEDIATE INCENTIVE CONDITIONS IN TERMS OF AVERAGE ERRORS PER TRIAL

the animals had shown no progress in learning for 50 trials past, they speedily began to learn under the new conditions. As will be seen from Figure 10, by the 105th trial all 9 animals had reached the degree of mastery required under Norm B. The change in conditions thus brought about almost immediate learning. This indicates that the animals were not lacking in ability to learn the maze and hence failure to learn up to the 99th trial was probably due to the factor of delay.

Figure 11 shows that the average time per trial decreased very markedly after the change in procedure was introduced. On the 101st trial the curve descended to a point lower than had been reached in the 95-99 trials (delayed incentive conditions). This indicates that the longer time per trial was probably due to the conditions of delay and not to a naturally slower speed of running in the case of these animals. Behavior observations made by the experimenter support these

conclusions. During the trials in which the incentive was delayed, the animals appeared to be less motivated, running slowly through the maze in a somewhat hesitant manner as above mentioned. Under the immediate incentive conditions, however, they ran quickly and directly through the maze to the food box, resembling in this respect the control-group animals in their behavior.

The error curve (Figure 12) shows the same general tendency as the time curve. The curve descended on the 102nd trial to the zero line. The general level is considerably lower than that of the 95-99 trials (delayed incentive conditions). This supports our conclusion that failure to learn up to the 99th trial was probably due to the conditions of delay rather than to inability to learn. The nature of the errors made previous to the 100th trial also offers corroborative evidence. The animals persisted in making one or two errors, going into the same cul-de-sac each time, which would suggest that the motivation was not strong enough to bring about perfect learning. In several cases, animals would run three perfect trials out of four and then make errors on the following trials so that the norm was not reached for many trials later. Evidently the delayed-incentive conditions worked against consistency in errorless runs since all animals reached Norm A by the 50th trial, while under the higher norm 9 had not learned by the 99th trial. That is, by reducing the motivation, delay operated to lower the quality or degree of perfection to which the habit was developed.

TABLE 19

EFFECT OF CHANGE IN PROCEDURE FROM DELAYED TO IMMEDIATE INCENTIVE CONDITIONS IN TERMS OF AVERAGE TIME PER TRIAL (The 9 animals which had not reached Norm B* by the 99th trial.)

Trial	Average time in seconds
95	22
96	23
97	27
98	35
99	35
Change to immediate incentive conditions	
100	26
101	19
102	11
103	8
104	9
105	8

*Four perfect trials out of five.

TABLE 20

EFFECT OF CHANGE IN PROCEDURE FROM DELAYED TO IMMEDIATE INCENTIVE CONDITIONS IN TERMS OF AVERAGE ERRORS PER TRIAL (The 9 animals which had not reached Norm B* by the 99th trial.)

Trial	Average errors
95	2
96	2
97	2
98	3
99	2
Change to immediate incentive conditions	
100	1
101	1
102	0
103	0
104	1
105	1

*Four perfect trials out of five.

In relating our results to those of previous investigators, we find that few studies are comparable. Simmons (6) used a 2-hour period of delay, so naturally no comparison with the present work, which was re-

stricted to much shorter periods, is possible. Watson (14) found that a delay as short as 30 seconds had no effect upon speed of learning. However, the interval he used was only half as long as our shortest, so the results are not comparable.

In a former study made by the writer (8), intervals of delay of 1 minute and 5 minutes were found to have no effect on speed of learning. In the general tendency shown, this finding would agree with Watson's conclusion, but is not supported by the present experiment in which all periods of delay employed (including a 1-minute and a 5-minute period) decreased the speed of learning. However, the previous study differed from the present one in one important respect: the animal was delayed in the same compartment with the food. That is, in the former experiment the animal was directly stimulated by the presence of the unobtainable food, whereas in the present case the direct stimulation of the food could occur only after the animal was released from the delay compartment into the food box. In the present experiment the matter of place of delay was much better controlled—the delay compartment was entirely separated from the food compartment. Evidently the situation of being delayed in the same place with the food, even though the latter be inaccessible, has little or no effect on the fixation process. While such a situation involves temporal delay, the pattern of the performance of running the maze is not definitely broken since the animal is not delayed until it comes upon the spot where the food is located. Our present technique involved not merely

temporal delay but temporal delay at a spatial position which interrupted the general performance pattern of reaching the food.

Perhaps the conditions in our present experiment may be said to be analogous to the situation of children, at a birthday party, who are not allowed to enter immediately the room where the birthday cake is with its candles and decorations, but are made to wait in an anteroom. The former study might then be analogous to the situation in which the same children are not detained in an anteroom but are allowed immediate access to the refreshment room. However, they are prevented from touching or eating anything for an interval of time. The latter situation has the added element of direct stimulation of the desired objects, while the former involves mere knowledge about them. Watson, who also did not use the anteroom technique, but delayed the animals in the same compartment with the food, obtained similar results with those of the previous study of the writer, but different from those in the present experiment.

The results here obtained seem to show clearly that delay decreased the drive as measured by rate of fixation. In the case of all of the delay groups, the rate of learning was reliably slower than that for the control group, in terms of trials and errors. The fact that running time was increased somewhat, with longer delays, indicates a motivation difference which, however, did not affect measurably the rate of fixation. Obviously, trials and errors are rather gross units of measurement of efficiency and if finer units could have

been used, a decreased efficiency reflecting the slowing down in running time might have been found. On the other hand, there is no need to suppose that speed of maze running is perfectly, or even highly, correlated with rate of fixation.

There is some indication that delay affected the quality of the learning, i. e., the habit was not formed as perfectly under the delay conditions, as seen by a comparison of results under the two norms of mastery. Although the animals in all groups had attained the lower norm (Norm A)[3] by the 50th trial, 9 of them had failed to learn under the higher norm (Norm B)[4] by the 99th trial. Delay had apparently decreased the drive in these animals and there was insufficient motivation to bring about further perfection of the habit. This interpretation is borne out by the fact that the 9 animals immediately developed the habit to the higher level (Norm B)[4] when the delay was eliminated.

It would seem to be impossible to relate our findings in any very important way to the law of effect as formulated by Thorndike. Our results agree with an increasingly large body of data showing the advantageous effects of motivated over unmotivated learning situations. If the terms "satisfying state" and "annoying state," as employed in the statement of the law of effect (7, p. 4), be taken in their usual psychological connotation as indicative of the subjective states of the organism, then naturally our findings could not be

[3]Two perfect trials out of three.
[4]Four perfect trials out of five.

stated in terms of this law since we have no index of the subjective states of our animals. It might be argued that they "enjoyed" the delay in some anticipatory way with as much cogency as that they were "annoyed" by it. The drive and incentive values obtained serve as objective indices of certain tendencies of the organism under the various conditions of motivation employed—and that is all that can be said. The argument covering this point has been made by Carr (1) and other writers.

As a corollary to the law of effect, Thorndike develops the principle that the strength of the bond is determined by the temporal closeness of the response and the satisfying or annoying state which follows. If we assume, as Thorndike seems to, that the incentive (food) produces a satisfying state, then our results would suggest that very definite restriction must be placed upon the value of the temporal factor in this type of learning. For, while any interval, within the limits investigated, cuts down very markedly the efficiency of the learning process, the longer intervals were hardly more effective than the shorter. Our results do not afford us a basis for conjecture as to whether delay operated as a positive "punishment" or merely as a distraction from the incentive situation in a purely negative sense, nor do they offer any clues as to the physiological (or neurological) processes underlying the behavior called out.

C. Summary of Results

Norm A[5]

1) An interval of delay as short as 1 minute between the running of the maze and the feeding response markedly decreased the rate of learning, in terms of the scores for trials, errors, and time. (The increase in trials taken to learn was 97 per cent; in errors, 85 per cent; in time, 112 per cent.)

2) Longer delay periods of 3 minutes, 5 minutes, and 7 minutes did not further decrease the speed of learning, as indicated by the scores on trials and errors. The time scores, however, were considerably lengthened as the interval of delay increased in length, indicating a slower rate of progress through the maze.

Norm B[6]

1) When a high norm of mastery (four perfect trials out of five) was used, 9 of the 105 animals failed to learn by the 99th trial, although all had learned by the 50th trial under Norm A.

2) Change of conditions from delayed to immediate incentive had a markedly favorable effect on the performance of the above-mentioned 9 animals. Time and error scores decreased immediately and all of the animals learned within 5 trials after the change in procedure, although they had made little or no progress for approximately the last 50 trials under the delayed incentive conditions.

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[5]Two perfect trials out of three.
[6]Four perfect trials out of five.

IV

DISCUSSION AND COMPARISON OF OBSTRUCTION AND LEARNING METHODS

In a comparison of the results obtained in the two experiments it is essential to have clearly in mind the method and procedure employed in each experiment. The most important differences in method have been arranged in tabular form as follows:

1) The length of the test period was arbitrarily limited to 20 minutes in the obstruction experiment, whereas time per trial was determined by the animal and varied from time to time in the case of the maze experiment.

2) Only a single test period was given each animal in the Obstruction Method, hence only a short time required per animal. No animal in the longest delay group (3-minute) required a longer time than one hour for the complete test. In the maze study, however, one trial a day was given until the maze had been learned, and thus the experiment extended over a much longer period of time per animal. An animal in the 3-minute group might require as long as three hours of testing time.

3) The period of starvation was 48 hours in the obstruction study. This period was used in order to get the maximal state of the hunger drive which should best bring out the effects of delay. In the maze experiment a period of 24 hours was used, since one trial per day was given.

4) The number of intervals of delay was determined by the number of crossings possible within the 20-minute period in the obstruction study. None of our animals reached the theoretical limit which has been shown to be about 44 crossings (9). On the other hand, the number of delay periods per trial in the learning experiment naturally was limited to one, since only a single daily trial was given.

5) In reacting to the incentive situation in the obstruction experiment, the act of securing the incentive did not need to be learned. That is, a more direct measure of drive was obtained, largely uncomplicated by the chance factors that always operate in a learning situation of the maze type.

6) The obstruction study involved "punishment" (shock), whereas the maze involved no punishment, but was a type of free activity which seems to be natural to the rat.

7) Fewer chance factors enter into the obstruction test, since such factors as illumination, sex drive, emotional disturbance, etc., could be more carefully controlled. The fact that only a single test period involved but one incentive situation, while the maze involved many incentive situations distributed over a much longer period of time, also made possible better control of conditions in the obstruction experiment than in the maze experiment.

It is apparent from the differing nature of the methods employed in this study that only general comparisons of the effect of delay can be made. In order to compare the general trend of the results in the ex-

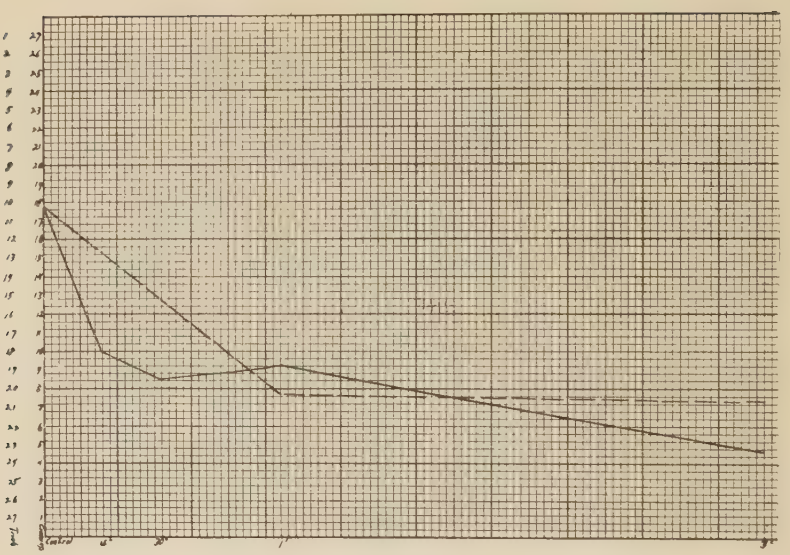

FIGURE 13

MAIN RESULTS IN OBSTRUCTION AND MAZE EXPERIMENTS

The solid line represents the average number of crossings for the combined (male and female) groups (Obstruction Method). The dash line represents the average number of trials required to learn (Maze Experiment).

periments, curves were constructed on the basis of the main results in each experiment as shown in Figure 13. Since no comparison is possible beyond the 3-minute interval, the curve for the maze was not extended beyond this point. It will be seen from the curves that a delay of 1 minute markedly decreased the drive and to much the same extent in both experiments. We do not know what effect shorter delays such as 15 seconds and 30 seconds might have had in the maze-learning experiment. During the progress of the maze experiment, no further decrease in the drive was

obtained with the longer delays of 3 minutes and 5 minutes, so it appeared to be of more interest to use a longer interval of 7 minutes in an attempt to determine whether the plateau effect was a real tendency or not. It would have been interesting also to study the effect of intervals shorter than 1 minute, but this was impossible without undue extension of the experiment.

In general, the same tendency is apparent in both experiments; namely, that even a short delay decreases the hunger drive, as measured by the methods used. The longer delays studied had little effect except that of a second drop in the curve of some magnitude in the obstruction experiment. The study of still longer periods of delay in the maze-learning experiment might reveal a tendency to decreased drive in the learning scores similar to that noted in the obstruction experiment. It is clear, however, that the most important decrease in drive is induced by very short delays, since the rate of decrease as between 15 seconds and 3 minutes in the obstruction experiment is only about 50 per cent as great as that between 0 and 15 seconds, even when no allowance is made for the difference in increments of delay in the two cases (2 ¾ minutes in the former and 15 seconds in the latter).

From the standpoint of both the method and procedure, and the results, it will be seen that the Obstruction Method of measuring drive is more adequate than the learning method in many respects. As above noted, the Obstruction Method is superior in that it furnishes a more *direct* measure of drive, uncomplicated by the factor of fixation; the technique is better

standardized and controlled than the maze method and hence fewer chance factors enter into the drive index. Furthermore, the time consumed in obtaining an index of drive is much less than half as long as that required in the direct maze-learning method.

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L'EFFET D'UN STIMULUS RETARDÉ SUR L'ÉLAN DE FAIM CHEZ LE RAT BLANC

(Résumé)

L'effet des délais courts entre l'exécution et le don du stimulus a été mesuré chez le rat blanc par deux méthodes: (1) la méthode des obstacles, et (2) l'apprentissage d'un labyrinthe. Dans la première méthode les périodes du délai ont été de 0, 15 secondes, 30 secondes, 1 minute, et 3 minutes. On a affamé les animaux pendant 48 heures, une période montrée optimum avec cette méthode pour des rats âgés de 185 jours. Des périodes de 15 secondes, 30 secondes, et 1 minute ont diminué l'élan au même degré (43%), tandis que le délai de 3 minutes l'a diminué encore plus. A propos de l'apprentissage du labyrinthe, on a mis des périodes de 0, 1, 3, 5, et 7 minutes entre le parcours du labyrinthe et la période ordinaire d'alimentation après un manque de nourriture pendant 24 heures, les épreuves étant données une par jour, et les rats âgés de 60 jours. Les délais ont été presque également efficaces, la quantité de cet effet étant presque de 100% en termes des épreuves nécessaires pour atteindre la norme de deux épreuves parfaites sur trois. Quand on a exigé quatre épreuves parfaites sur cinq, neuf animaux—tous des groupes de plus grand délai—n'ont pas appris en 99 épreuves, mais ont fini l'apprentissage en cinq épreuves quand on a éliminé la période de délai.

HAMILTON

ÜBER DIE WIRKUNG DES VERZÖGERTEN LOCKSMITTELS BEI DEM HUNGERTRIEB MIT DER WEISSEN RATTE

(Referat)

Die Wirkung kurzer Verzögerung zwischen Leistung und Erhalten des Lockmittels wurde bei der weissen Ratte durch zwei Methoden bemessen: (1) die Hindernismethode, und (2) das Erlernen des Labyrinths. Bei der ersten Methode waren die Intervalle der Verzögerung 0, 15 Sekunden, 30 Sekunden, 1 Minute, und 3 Minuten. Man liess die Tiere 48 Stunden fasten, ein Zeitraum den man als optimum bei dieser Methode, bei Ratten im Alter von 185 Tagen, befunden hatte. Intervalle von 15 Sekunden, 30 Sekunden, und einer Minute reduzierten die Zeitdauer in ungefähr gleicher Weise, (i.e., 45%), eine Verzögerung von 3 Minuten bewirkte eine weitere Abnahme. Bei dem Experiment mit dem Labyrinth, wurden Intervalle von 0, 1, 3, 5, und 7 Minuten zwischen dem Lauf durch das Labyrinth und der regelmässigen Fütterungszeit eingeschaltet, nach einer Fastenzeit von 24 Stunden, bei täglich einem Experiment mit Ratten von 60 Tagen. Die Verzögerungen waren ungefähr gleich wirksam, die Totalwirkung betrug fast 100% im Vergleich zu der Anzahl der Versuche die nötig sind die Norm von zwei vollkommnen Versuchen aus je dreien zu erreichen. Wenn vier vollkommne Versuche aus je fünf gefordert wurden, so lernten 9 Tiere—alle aus der Gruppe mit längerer Verzögerung—dies selbst nicht in 99 Versuchen, lernten es jedoch in fünf weitern Versuchen nachdem man das Verzögerungsintervall ausgeschaltet hatte.

HAMILTON

ЭФФЕКТ ЗАДЕРЖАННОГО ПОБУЖДЕНИЯ ПРИ ГОЛОДАНИИ У БЕЛЫХ КРЫС.

(Реферат).

Действие кратковременной задержки между получением побуждения и исполнением было измерено у белой крысы путем двух методов: (1) методом затруднения при продвижении к цели и (2) обучением в лабиринте. При применении первого метода промежутки между задержками были 0 сек., 15 сек., 30 сек., 1 минута и 3 минуты. Животные были подвержены голоданию в течение 48 часов, что при данном методе оказалось нижней границей оптимума для крыс возраста 185 дней от роду. Промежутки в 15 сек., 30 сек. и 1 минуту замедляли выполнение приблизительно в одинаковой степени (43%), тогда как трехминутная задержка вызывала дальнейшее замедление. В связи с обучением в лабиринте, промежутки в 0, 1, 3, 5 и 7 минут устраивались между окончанием пробега лабиринта и регулярными периодами кормления после 24-часового голодания, опыты, как правило, устраивались раз в день, брали крыс 60-дневного возраста. Задержки дали приблизительно одинаковый эффект, сумма всех действий составляла почти 100% в величинах опытов, требующих, как предела достигаемости, того, чтобы из трех опытов было два удачных.

Гамильтон (Hamilton).

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